Check List 10(3): 524–528, 2014

ISSN 1809-127X (available at *www.checklist.org.br*)

Check List
Journal of species lists and distribution

Lists of Species

Checklist of zooplankton from the upper Ipanema River (Pernambuco), an intermittent river in semi-arid Brazil

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Abstract: The present study aimed to survey the zooplankton composition (Rotifera, Cladocera and Copepoda) in the upper Ipanema River, an intermittent river affluent of the São Francisco River in semi-arid Brazil. Sampling was performed during the wet (April and July 2007) and dry (October 2007 and January 2008) periods. Thirty species were recorded, Rotifera being the richest with 25 species. Among the Rotifera families recorded, Brachionidae and Lecanidae showed greater number of species, in contrast with lower richness of Cladocera and Copepoda.

DOI: 10.15560/10.3.524

Introduction

The zooplankton is composed of organisms that respond rapidly to changes in physical and chemical characteristics of the environment (Simões *et al*. 2008). Therefore, they represent important indicators of the ecological integrity of riverine systems (Lampert 1997) and have been recognized as important energy resources for fish and other aquatic organisms (Medeiros and Arthington 2008). In variable environments, such as intermittent rivers, zooplankton is subject to strong variations in numbers and species composition, resulting from the extremes of flooding and drying (Medeiros *et al*. 2011).

Intermittent streams and rivers are common systems in the semi-arid region of Brazil, with wide distribution and high species diversity (Maltchik and Medeiros 2006). These systems are characterized by important periods of no flow interspaced by a short flooding season (Maltchik and Florin 2002). During the dry season, the aquatic fauna survives in temporary and semi-permanent pools in the river bed, which harbor food resources and are also used as breeding sites (see Stanley *et al.* 1997; Medeiros and Maltchik 2001).

Policies for water management in semi-arid rivers of Brazil emphasize the construction of dams to create reservoirs for water storage as well as water diversions. Despite being important social and economical features, these policies compromise the diversity and composition of species in intermittent aquatic ecosystems affecting their ecological integrity (see for instance Medeiros *et al*. 2006; Medeiros *et al.* 2011). Changes in water flow in riverine systems have been reported to disrupt biological processes, affecting patterns of species distribution, dynamics of colonization and life cycle (Maltchik 1999; Simões *et al*. 2008).

Given the importance of zooplankton in intermittent streams, surveys in these systems must also emphasize species richness and distribution, since such studies will help to increase efficiency in estimations of species diversity. Therefore, the species lists generated will contribute to the understanding of species occurrence at different scales and can be used as a tool in impact assessments. Such information enables decision-makers to better incorporate biological processes in conservation and management efforts.

The objective of this study is to present a list of species of zooplankton (Rotifera, Cladocera and Copepoda) from the upper Ipanema River, an intermittent river in semi-arid Brazil. We provide additional comments on main taxa distribution along the river.

Materials and Methods

Study area

The present study was performed in the upper Ipanema River, in the Buíque/Vale do Ipojuca region (*sensu* Tabarelli and Silva 2003). This area is classified as being of extreme biological importance and was identified as priority area for biodiversity conservation in the Caatinga by Silva *et al*. (2003), because they present high diversity of species and are rich in endemism. Located around the town of Buíque in central Pernambuco (PE) (Figure 1) this area is drained mostly by affluents of the São Francisco River (e.g. Moxotó and Ipanema rivers). The average annual temperature and precipitation are 25°C and 1095.9 mm, respectively. Rainfall is concentrated between April and June. Altitude ranges between 800 and 1000 m (Rodal *et al.* 1998; see Farias *et al*. 2012 for details on physical and chemical water variables of the study sites).

Data collection and analysis

Four study sites were established and sampled four times during the wet (April and July 2007) and dry (October 2007 and January 2008) seasons. Study sites were distributed along the upper reaches of the Ipanema River: Riacho Cruz da Aranha - RCA (08°39′18.36″ S, 37°02′09.12″ W), Açude Dona Nice - ADN (08°43′13.02″ S, 36°58′27.24″ W), Sítio Três Riachos - STR (08°43′17.04″ S,

36°59′33.36″ W), and Poço da Divisão - PDD (08°54′20.76″ S, 37°05′02.10″ W) (Figure 1). RCA and PDD sites dried out before the last sampling occasion, so they present fewer samples (Table 1).

Zooplankton was collected using a plankton net (opening diameter 30 cm, 70 cm long and mesh size 60 µm). The net was towed at three different locations (henceforth termed sample) in each of the three study sites for a distance of 10 m on the surface of the water at dusk. To minimize variation in sampling efficiency across samples, velocity and length of tows were similar and the net was washed between each tow to prevent clogging. The zooplankton collected was anesthetized with commercial sparkling water and preserved in 4% formalin. Sucrose was added to the preserved sample to prevent cladocerans from losing eggs and to minimize carapace distortion (Medeiros *et al*. 2011). In the laboratory, three sub-samples of 1 mL were taken from each sample and all individuals were identified and counted in a Sedgewick-Rafter counting cell (Koste 1978; Elmoor-Loureiro 1997, among others). Only rotifers, cladocerans and copepods were considered in the present study. Species accumulation and Bray-Curtis distance curves (and their standard deviation) were calculated on PC-ORD 4.2 (McCune and Mefford 1999) to evaluate the adequacy of sample size (naupliar stages were included in this analysis). The distance curve represents the distance between the centroid of a sample and the centroid of the data set. That means that the more representative is a sample the lower the distance between it and the dataset (McCune and Grace 2002).

Results

The plankton fauna in the Ipanema River was composed of 30 species distributed among the Rotifera, Cladocera and Copepoda (Table 1). Naupliar stages of Copepoda were also recorded. Rotifera was the richest group with 25 species, being also frequently recorded across sites and sampling occasions. Among the Rotifera, Brachionidae was represented by 11 species and Lecanidae presented 5 species. All other Rotifera families were represented by one or two species. Cladocera and Copepoda were observed in lower richness, compared to Rotifera, with the Cladocera being found in fewer sites. Copepoda was dominated by naupliar stages, which were found in all sampling occasions and sites, and to a lesser extent *Mesocyclops*. A higher number of species was observed during the April collection for all study reaches with subsequent reduction in species numbers. The Açude Dona Nice (ADN) site showed higher overall richness, whereas the Riacho Cruz da Aranha (RCA) site showed the lower overall richness values (Figure 2).

Species accumulation and distance curves (Figure 3) showed that 21 samples will yield over 29 taxa for the study stream (95% of the species), with more samples yielding relatively small increases in the number of taxa. Similarly, 21 samples will yield a Bray-Curtis distance of 0.05, measured between the centroid of the sample and the centroid of the whole dataset, compared with the greater distance from the centroid of the first sample, which was 0.63. That means that, further increases in sampling render the sample only slightly more similar to the whole dataset. These results indicate that sampling effort was representative, with at least 95% of the taxa being captured at 52.5% of the effort employed. Furthermore, first- and second-order Jackknife estimated a total richness of 33, out of the 31 taxa observed (including nauplii).

Discussion

The present study, showed that rotifers (Brachionidae and Lecanidae) dominated in terms of richness. This has been reported in other studies in semi-arid intermittent rivers o Brazil (Simões *et al*. 2008; Medeiros *et al*. 2011), and is explained by the less specialized feeding habits of the group, as well as r-strategist/opportunistic characteristics, such as high fecundity and short developmental rates (Allan 1976). These characteristics have been argued

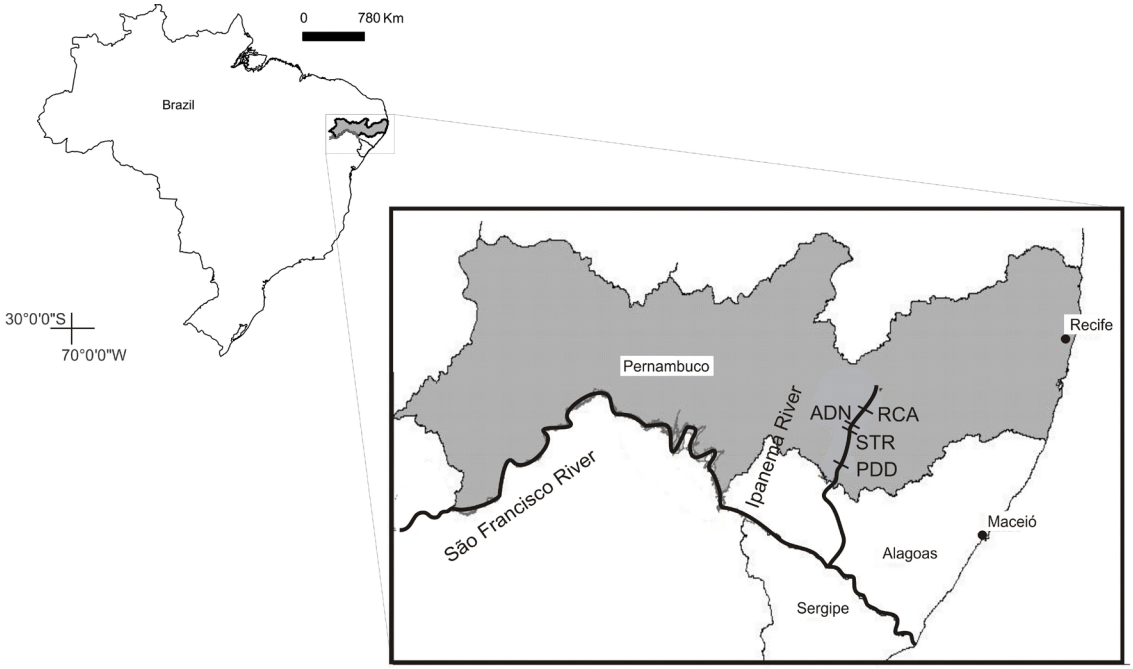

Figure 1. Study area with the location of the Ipanema River in the states of Pernambuco and Alagoas and the study reaches during the hydrological cycle of 2007/2008. RCA, Riacho Cruz da Aranha; ADN, Açude Dona Nice; STR, Sítio Três Riachos and PDD, Poço da Divisão.

to have great importance in patterns of distribution of species of zooplankton in the highly seasonal Brazilian semi-arid rivers (Medeiros *et al*. 2011). Brachionidae is mostly a planktonic group, being therefore, highly subject to variations in water flow, whereas Lecanidae is mostly litoraneous, associated with the benthos and periphyton (Almeida *et al.* 2006). These families are considered important indicators of physical and biological conditions in the environment, contributing with high numbers of individuals (see Vieira *et al.* 2009).

Cladocera and Copepoda were observed in lower richness, compared to Rotifera. These taxa are more selective to environmental change, both physical and in resource availability (Walz and Welker 1998). Restrictions in habitat size during the dry season and variations in flow during the wet season may be important factors limiting the richness of species of these groups in intermittent rivers (Crispim and Watanabe 2001), but local patterns of predation by fish and dissolved nutrient dynamics may also be playing an important role in the abundance and diversity of species from these groups (Crispim and Watanabe 2000; Medeiros and Arthington 2008). Larval stages of Copepoda (Nauplii) were highly frequent during the present study. This group of organisms has been reported as first colonizers in temporary aquatic habitats (Cole 1966; Frisch and Green 2007), and therefore, their high frequency should be expected in the semi-arid intermittent river studied.

In April, the Ipanema River showed surface water flow, which was also present during the July collection but in lower magnitude (Farias *et al*. 2012). Therefore, it is likely that flooding increased the overall number of taxa. Greater richness was also observed in the Açude Dona Nice site (ADN). This is a reservoir that neither dried out nor decreased greatly in volume during the study period, such as the other study sites and therefore had greater water retention time. Studies have proposed that the inadequacy in water residence for intermittent streams is a limiting factor for zooplankton diversity, and therefore, larger and more permanent reservoirs are

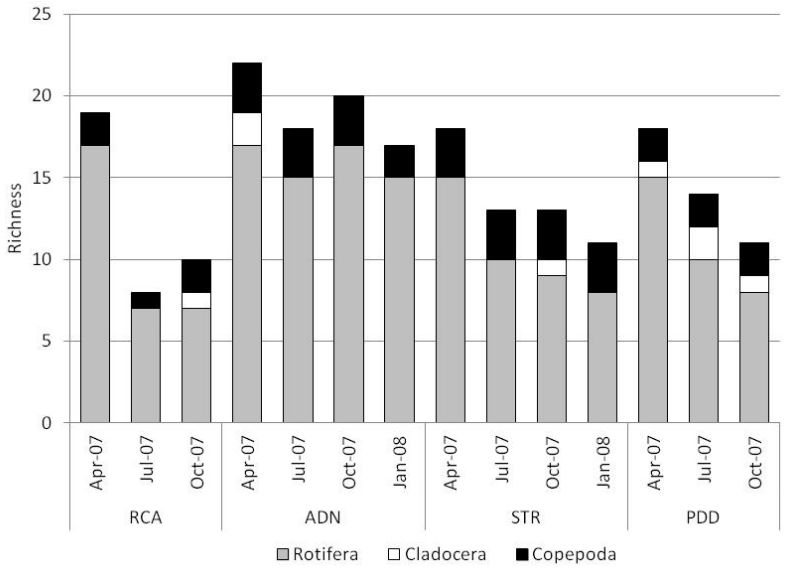

Figure 2. Species richness of Rotifera, Cladocera and Copepoda in the study sites during the hydrological cycle of 2007/2008. RCA, Riacho Cruz da Aranha; ADN, Açude Dona Nice; STR, Sítio Três Riachos and PDD, Poço da Divisão.

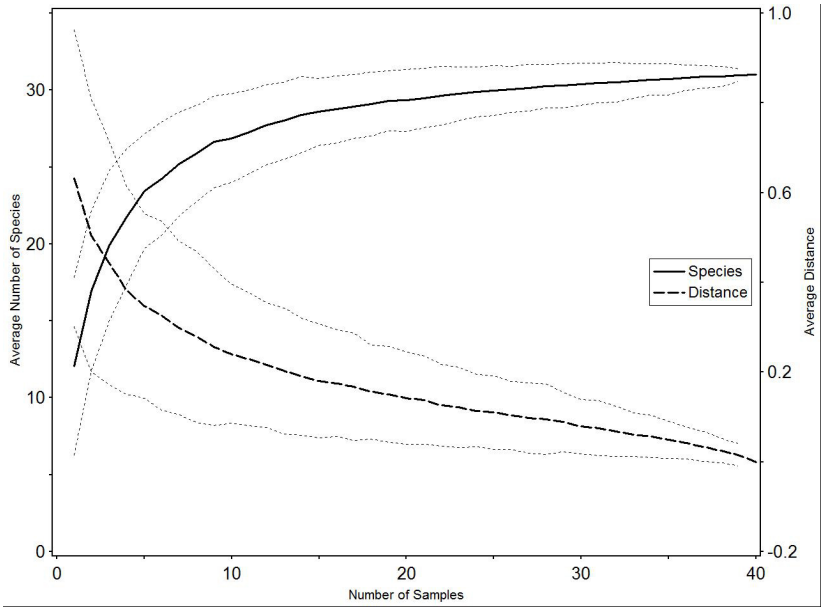

Figure 3. Accumulation and distance curves (± SD) used to assess sample adequacy for the zooplankton samples in the Ipanema River.

expected to hold greater number of species (Medeiros *et al*. 2011).

This study provided a list of zooplankton species for the upper Ipanema River, an intermittent river in semi-arid Brazil, and relatively unknown system with regard to the zooplankton. Account for spatial and temporal variation in species occurrence largely improves knowledge on this system and to the São Francisco River basin.

Table 1. Distribution and frequency of occurrence (%, F.O.) of zooplankton taxa in the upper Ipanema River (PE, Brazil) during the study period. Numbers in parenthesis (n) indicate number of samples per occasion. RCA, Riacho Cruz da Aranha; ADN, Açude Dona Nice; STR, Sítio Três Riachos and PDD, Poço da Divisão.

	RCA		STR			ADN					PDD				
	Apr/07 (n=3)	Jul/07 (n=3)	Oct/07 (n=3)	Apr/07 (n=3)	Jul/07 (n=3)	Oct/07 (n=3)	Jan/08 (n=3)	Apr/07 (n=3)	Jul/07 (n=3)	Oct/07 (n=3)	Jan/08 (n=3)	Apr/07 (n=3)	Jul/07 (n=3)	Oct/07 (n=1)	F.O.%
ROTIFERA															
Brachionidae															
Brachionus angularis Gosse, 1851			X	X	X	X	X	X	X	X	X	X		X	78.6
Brachionus calyciflorus Pallas, 1766	X		X	X	X	X	X	X	X	X	X	X	X	X	92.9
Brachionus caudatus Barrois & Daday, 1894	X			X		X	X	X	X	X	X		X		64.3
Brachionus dolabratus Harring, 1914								X							7.1
Brachionus falcatus Zacharias, 1898				X	X		X	X	X	X	X	X			57.1
Brachionus havanaensis Rousselet, 1911								X		X	X				21.4
Brachionus quadridentatus Hermann, 1783										X					7.1
Keratella lenzi Hauer, 1953				X	X	X	X								28.6
Keratella tropica (Apstein, 1907)	X	X		X	X	X	X	X	X	X	X	X	X	X	92.9
Platyias quadricornis (Ehrenberg, 1832)								X							7.1
Plationus patulus (Müller, 1786)	X								X	X	X		X		35.7
Philodinidae															
Rotaria sp.								X	X	X	X	X	X	X	50.0
Filinidae															
Filinia longiseta (Ehrenberg, 1834)	X			X			X	X		X	X	X			50.0
Filinia opoliensis (Zacharias, 1898)	X			X		X						X			28.6
Hexarthridae															
Hexarthra mira (Hudson, 1871)	X		X						X	X		X		X	42.9
Lecanidae															
Lecane bulla (Gosse, 1886)	X	X		X	X	X	X	X	X	X	X	X	X		85.7
Lecane hastata (Murray, 1913)	X			X					X			X			28.6
Lecane leontina (Turner, 1892)	X	X		X	X			X	X		X	X	X		64.3
Lecane luna (Muller, 1776)	X	X		X	X			X	X	X		X	X		64.3
Lecane lunaris (Ehrenberg, 1832)	X			X	X			X	X		X		X		50.0
Lepadellidae															
Lepadella sp.	X	X						X							21.4
Testudinellidae															
Pompholyx sulcata Hudson, 1885	X		X					X		X	X	X	X	X	57.1
Testudinella patina (Hermann, 1783)	X	X	X							X		X		X	42.9
Synchaetidae															
Polyarthra sp.	X	X	X	X	X	X		X	X	X	X	X		X	85.7
Trichocercidae															
Trichocerca sp.	X		X	X		X			X	X	X				50.0
CLADOCERA															
Chydoridae															
Alonella brasiliensis Bergamin, 1935						X		X				X	X		28.6
Daphniidae															
Ceriodaphnia cornuta Sars, 1886													X		7.1
Moinidae															
Moina sp.			X					X						X	21.4
COPEPODA															
Nauplius	X	X	X	X	X	X	X	X	X	X	X	X	X	X	100.0
Calanoida															
Notodiaptomus sp.				X	X	X	X	X	X	X					50.0
Cyclopoida															
Mesocyclops longisetus (Thiebaud, 1912)	X		X	X	X	X	X	X	X	X	X	X	X	X	92.9

Acknowledgments: The authors are grateful to Prof. Cristina Crispim (UFPB) for help with the identification of zooplankton. Thais Melo is grateful to "Programa de Iniciação Científica UEPB/CNPq" for scholarship granted (PIBIC/CNPq/UEPB 2009-2010). This research was supported by funds from Edital MCT/CNPq 02/2006 – Universal, Proc. 477545/2006-8. Elvio Medeiros holds a Brazilian Research Council (CNPq) Research Productivity Grant (Proc. 312028/2012-1).

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Received: March 2013
Accepted: April 2014
Published online: July 2014
Editorial responsibility: Luís Ernesto Arruda Bezerra